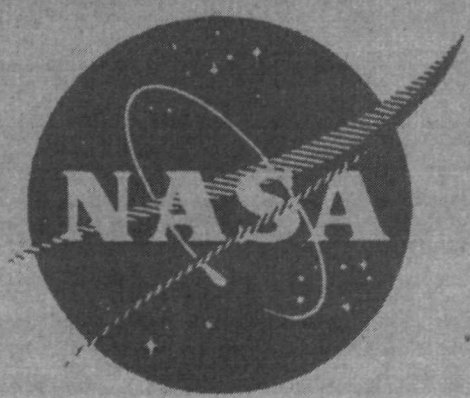
THE NASA ROLE IN MAJOR AREAS OF HUMAN CONCERN

SAFETY



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THE NASA ROLE

IN MAJOR AREAS OF HUMAN CONCERN:

SAFETY

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-Prepared by -

Industrial Economics Division
Denver Research Institute
University of Denver
Denver, Colorado 80210

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PREFACE

Understanding the social significance of America's civilian aeronautics and space effort has become increasingly difficult during the past five years. Whereas the missions of the National Aeronautics and Space Administration once figured prominently in discussions of public issues, increased interest in other national priorities has come to compete with, and often to dominate, concern about those missions. The study which generated this presentation was undertaken to facilitate more thoughtful discussion of NASA's activities by exploring how the achievement of mission objectives has contributed to beneficial changes occurring in six areas of major national interest: communication, transportation, environmental quality, safety, health care and work.

This statement focuses attention on the area of safety. After introducing some of the general factors that have affected progress in this area, NASA program elements are examined to illustrate relevant points of contact. Interpretive steps are taken throughout the statement to show a few of the more important ways people's lives have been affected as a result of the work of NASA and other organizations functioning in this area. The principal documents used and interviews conducted are identified after the conclusion of this statement.

This statement, it should be noted, is incomplete in many respects, primarily because it reflects only a small number of the technical, economic, and social forces affecting American life. Taken as a summary statement, however, it hopefully will provide a useful basis for better understanding of NASA's role in the national attempt to minimize the occurrence and severity of accidents.

SAFETY: PROTECTION THROUGH PREVENTION

Safety is like a sword that cuts two ways. In one direction, it promotes a systematic approach for neutralizing potential hazards before they become destructive; in the other direction, it presents a set of techniques for minimizing the harmful consequences of accidents once they happen.

Safety neutralizes hazards and minimizes losses.

Prevention and cure until recently have not been equally emphasized in most attempts to improve human safety. This may be due partly to the fact that so many accidents occur. According to the National Safety Council, home, work, and travel accidents in the United States during 1971 claimed the lives of 115,000 Americans and injured 11,200,000 others. The cost of those accidents in lost wages, medical fees, hospital expenses, insurance settlements, property damage and time lost totaled at least $29 billion.[1] The U. S. Public Health Service estimates that accident victims occupy one of every eight hospital beds in this country.[2]

Most safety concern has been keyed to minimizing losses.

By contrast, the total outlay on various measures for preventing accidents from happening amounted to only a small fraction of the $29 billion in damages, most of which was spent in automotive and large industrial accident prevention programs.[3] Though small in comparison to corrective efforts, the effectiveness of the preventive measures has been impressive. The rate of on-the-job accidental deaths, for instance, decreased 38 percent between 1948 and 1971, a period that saw a 42 percent growth in the work force together with a rapid increase in potentially hazardous mechanization. During the same period, the death rate in motor vehicle accidents decreased approximately 42 percent in terms of total vehicle miles driven.[4] Although much improvement still is needed in these areas, accident prevention programs have been making vitally important contributions to human safety.

Planned prevention, though modest, results in fewer accidents.

With its heavy involvement in developing manned systems, both aircraft and spacecraft, that are propelled by some of the most volatile chemicals ever developed and operated under maximum stress in hostile environments, NASA has become a major resource to the country in the new orientation toward preventive safety. This consideration of the NASA role in accident prevention focuses attention on improvements affecting the design and testing of equipment and structures, new ways of preventing unwanted fires, and a general overall approach the Agency has taken to prevent personal injury and the accidental loss of property.

NASA safety procedures emphasize accident prevention.

Equipment and Structural Safety

On the afternoon of December 15, 1967, during rush hour traffic the highway bridge across the Ohio River at Point Pleasant, West Virginia, began to vibrate. Suddenly the bridge collapsed, dropping 24 vehicles into the river; 46 persons were killed and nine injured. At the time of its collapse, the Point Pleasant Bridge was carrying a load well within its design capacity.[5]

To unravel the mystery of its collapse, and to help find ways of preventing similar tragedies in thousands of other bridges in the United States, a team of engineers from Batelle Memorial Institute was assigned the task of determining the cause of the accident. Their investigation revealed that a hidden crack in one of the bridge's elements caused the collapse. In effect, the bridge collapsed for the same reason that other structures like ships, storage tanks, aircraft and buildings can collapse when carrying loads well below what they were expected to carry: structural material loses its strength when a flaw of some kind acts to concentrate stresses in one small area. By using the "plane strain fracture toughness" test developed at NASA's Lewis Research Center, Batelle engineers were able to pinpoint the structural crack that caused the bridge failure.[6] This highly sophisticated technique for extrapolating results from tests on a single sample of a structural material enables engineers to determine exactly the weakening influence of cracks in that material.

The NASA-developed "fracture toughness" test helps explain and predict structural collapses.

The bridge collapse at Point Pleasant is a specific example of a much larger U. S. highway bridge safety problem. In a recent study, the Federal Highway Administration concluded that as many as 89,000 highway bridges may be "critically deficient."[7] As part of its total program to correct such deficiencies before they become disastrous, the Federal Highway Administration and NASA's Ames Research Center have established a joint bridge-monitoring project. By using the Ames-conceived "randomdec" structural analysis method, engineers are able to monitor random vibrations of a bridge and detect resulting changes in its structure that may lead to its collapse.[8]

NASA's "randomdec" method also is used in structural analysis.

During the past decade, computer programs have become an increasingly important tool used by engineers to perform more thorough analyses of civil structures and machines. A computer program developed by NASA and managed by the Langley Research Center, known as the NASA Structural Analysis Program (NASTRAN), for example, is being used by the Ford Motor Company for designing and analyzing various components of motor vehicles, such as the lower arm of the front suspension

NASTRAN provides low-cost, high quality computer assistance in designing safer structures.

system of an automobile; this arm is subject to a severe dynamic loading environment. A company spokesman indicates that such analyses have already saved several million dollars per year in test costs when compared with previously used methods. NASTRAN also has been used as the principal design tool for structural analyses of a new 40-story building in Chicago. By combining engineering technology with computer programming, designers have been better able to insure the safety of the structure and to reduce substantially the costs ordinarily associated with this aspect of engineering design.[9]

Fire Safety

Comfort and durability were uppermost in the minds of an Ohio couple sometime ago when they bought a nightgown for their four-year-old daughter. Yet, one evening the child, intent on getting a closer look at her pet bird, climbed onto a gas oven and accidentally jarred a burner knob. Instantly her nightgown burst into flames that burned more than 50 percent of her body. Ninety-seven days and eleven skin grafts later she was released from the hospital.[10]

Flammable fabrics present a continuous hazard.

This incident, one of the more than 2.5 million unwanted fires in 1970, illustrates not only the tragic consequences produced, but also how close daily activities bring many people to fire-caused disasters. The National Fire Protection Association (NFPA) estimated that in 1970 fires claimed the lives of 12,200 Americans and cost this country more than $2.5 billion. Clothing fires alone caused approximately 2,000 of those deaths and more than 200,000 injuries. Putting the fatal element of fires into perspective, NFPA points out that burn deaths are the third largest cause of all accidental deaths, exceeded only by deaths from motor vehicles and falls.[11]

Fires kill and maim thousands annually.

The drive to pass and enforce meaningful fire safety legislation is apparent in several sectors of government. Under the 1967 amendments to the Flammable Fabrics Act of 1953, for example, the National Bureau of Standards became responsible for setting flammability standards, including labeling for fabrics and other products, in order to protect the public against unreasonable risk of injury from fire. In addition to NBS, the National Aeronautics and Space Administration, the Department of Transportation, the Department of Health, Education and Welfare, the Social Security Administration, and other government agencies are now involved in generating or standardizing fire safety technology for applications ranging from jet aircraft and automotive interiors to the construction of nursing homes and hospitals.

More stringent fire safety standards are being developed.

NASA has been directly responsible for generating many important developments in fire safety. The Agency, for example, has made significant advances in dealing with problems of handling flammable materials, in developing numerous new instruments and techniques for flammability testing, and in using fire resistant materials in structures and systems. Few organizations, of course, have had to cope routinely with fire and explosion hazards comparable to those involved in manned space flight. Many of the fuels used, such as liquid oxygen and liquid hydrogen, are among the most volatile substances known and must be handled in immense quantities. Similarly, most fire hazard problems are not comparable to the one of locking up several persons and a vast array of electrical gear into a tightly-sealed capsule filled with an atmosphere of pure oxygen. Fire in such an atmosphere turns most conventional plastics, fabrics and paints into near-explosive fuels. Thus, NASA had had to develop many different fire-proof materials, flammability tests, and flame control techniques.

NASA has contributed technology that facilitates the standardization effort.

Many NASA-developed fire-proof materials are being tested for use in nonaerospace applications. The International Association of Firefighters, for example, has worked with NASA to design protective suits from new materials developed for the space program; fire safety specialists from NASA's Manned Spacecraft Center and the Houston Fire Department have developed and successfully evaluated these suits. Further testing is being conducted in cities throughout the United States. Welson and Company, a manufacturer of special-purpose garments, conducted a similar program for the State of Connecticut. Using technology and materials developed in the space program, Welson fabricated eight firesuits, four of which are being evaluated by fire departments within the state. Special paints that emit a flame-retarding gas when heat is applied have been studied for years by NASA's Ames Research Center; such paints are being evaluated by the National Association of Home Builders for protection of plastics used in housing construction. Special foams, developed at Ames, also retard fire propagation, and have excellent insulative qualities as well. Many of these new materials are being tested by the Garrett Corporation for use as carpeting, seats, head rests, decorative paneling, curtains, insulation and flame barriers in aircraft. Additional tests for turning the promise of these new materials into nonaerospace fire safety applications are planned at the Manned Spacecraft Center.[12]

Fire-proof materials developed for NASA are being tested in several nonaerospace applications.

By considering the magnitude of fire control requirements in the context of a society growing larger and more complex, it is apparent that fire control methods as well as the materials used in products, structures, and operating systems can be improved. Society's need for fabrics, housing, and vehicles of all types

Method for neutralizing fire hazards are improving.

that will not support unwanted fires may not be realized in the immediate future; however, many improvements in fire safety are flowing out of this country's civilian aeronautics and space program.

Industrial Safety

Guaranteeing the integrity of highly stressed structures and reducing or eliminating certain types of fire hazards are far from being NASA's only involvement in the area of human safety. The Agency, for example, along with the Department of Defense and the Atomic Energy Commission, has been a leader in establishing and using a comprehensive approach to industrial accident prevention known as "system safety." Air Force, AEC and NASA engineers pioneered in formulating and applying comprehensive analytical strategies for predicting how a system can fail and devising ways to avoid failure.[13]

NASA has required the development and use of system safety concepts in manufacturing.

Perhaps the most significant indication of the power of the system safety approach in practice is the outstanding safety record of the aerospace industry. Despite the obvious dangers associated with handling hazardous materials and machinery, the aerospace industry was second only to the automotive industry in work safety performance during 1971. The National Safety Council presented the industry with a special award for this achievement.[14]

Aerospace has achieved a remarkable work safety record.

System safety techniques have already begun to surface in nonaerospace and nondefense industries through safety consultants, university courses, special publications, and, to some extent, by a new government agency called the Occupational Safety and Health Administration.[15] The deaths and miseries of many American workers make the recent surge of interest in system safety easy to understand: at least 14,200 persons died because of on-the-job accidents in 1971, and more than 2,300,000 others suffered disabling injuries. According to National Safety Council estimates, work-related 1971 accidents cost the nation in excess of $9.3 billion in lost wages, medical expenses, insurance investigations and time lost.[16]

14,200 persons died in 1971 on-the-job accidents.

During the development of the Apollo Program spacecraft, the complexity of the vehicle systems and the pressures of mounting costs and time schedules forced NASA and its contractors to establish a viable overall approach for assessing and managing the risks associated with manned space flight.[17] These considerations, with the added emphasis of the Command Module fire at Cape

Constructing and operating Apollo spacecraft provided a major proving ground for the system safety concept.

Kennedy in early 1967, led the Agency to organize the Office of Manned Space Flight Safety and to implement formal system safety programs at all NASA field centers and at major contractor facilities. The Agency's resulting record of superior safety performance underlines both the strength and the flexibility of the systems safety approach in practice.

Since 1968, NASA has supported the operation of the Aerospace Safety Research and Data Institute (ASRDI) at the Lewis Research Center to expedite the flow of technical knowledge from the laboratory and the library to the individual with a safety problem. ASRDI was established to support NASA, its contractors, and the aerospace industry with technical information and consulting on safety problems; to assemble a safety data center in which safety-related information is collected, validated, and assembled for maximum use in solving engineering problems; and to stimulate research required to fill gaps in existing safety information. Among its most remarkable achievements, ASRDI has developed a unique data base management system unparalleled in capability anywhere in the world since it provides a single point for assessing the dozens of different multi-disciplinary dimensions of the aerospace safety field.[18]

NASA's ASRDI is making significant contributions to human safety.

The influence of systems safety in industries outside aerospace and defense has yet to become widespread. Charles O. Miller, director of the National Transportation Safety Board's Aviation Safety Bureau, notes, however, that the indications for more general use of this approach to accident prevention are quite favorable. He points out that such organizations as the Air Transport Association, the National Safety Council, the National Transportation Safety Board, as well as several large corporations, are making major efforts to facilitate the adoption of the system safety approach in dozens of industries.[19]

Accident Prevention: A Renewed Emphasis

The complexity of aerospace equipment coupled with the hazardous environments that pilots, astronauts, and their equipment must confront have demanded the application of new ways of thinking about safety. Many times in the past preventive activity was not initiated until disasters occurred. Within the last ten years, however, the adequacy of this so-called "tombstone" approach has been challenged; in its place a comprehensive approach for identifying hazards and initiating preventive action has emerged. NASA is contributing to this movement by supplying technical information and supporting services to organizations concerned with the prevention of accidents.

Substantial progress has been made in neutralizing hazards of various kinds.

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